NOTE

RECOGNITION OF EMOTION FROM FACIAL, PROSODIC AND WRITTEN VERBAL STIMULI IN PARKINSON'S DISEASE

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Abstract

Although the basal ganglia are thought to be important in recognizing emotion, there is contradictory evidence as to whether patients with Parkinson's disease (PD) have deficits in recognizing facial expressions. In addition, few studies have examined their ability to recognize emotion from non-visual stimuli, such as voices. We examined the ability of PD patients and age-matched controls to recognize emotion in three different modalities: facial, prosodic, and written verbal stimuli. Compared to controls, PD patients showed deficits in recognizing fear and disgust in facial expressions. These impairments were not seen in their recognition of prosodic or written verbal stimuli. This modality-specific deficit suggests that the neural substrates for recognizing emotion from different modalities are not fully identical.

Introduction

Recognizing the emotions of others is important for nonverbal communication in humans, and facilitates social relationships. Facial expressions have been studied extensively in the fields of psychology and sociology, but the neural systems involved in the recognition of facial emotion remain unclear. Several recent neuropsychological studies have reported that patients with Parkinson's disease (PD), in which there is dysfunction of components of the basal ganglia, showed impaired recognition of facial expressions (Blonder et al., 1989; Jacobs et al., 1995a), suggesting the involvement of the basal ganglia in emotion recognition. However, there is contradictory evidence, as some studies have reported that PD patients' recognition of facial expressions was not impaired (Dewick et al., 1991; Adolphs et al., 1998).

Most previous studies used photographs of faces as stimuli, but static photographs may not be as readily recognizable as actual expressions, because they contain no dynamic information. Furthermore, most previous studies have combined all types of facial expression, and have not considered different facial expressions, such as a difference in recognizing happy and sad faces.

In this study, we examined the ability of PD patients to recognize facial expressions by using videotaped facial expressions, as well as photographs of faces, and made an emotion-specific analysis. We also used prosodic and written verbal stimuli to investigate whether the results were consistent over all sensory emotions, or were confined to a specific modality.

Materials and Methods

Subjects

Nineteen patients were tested. The severity of their symptoms was equivalent to Hoehn-Yahr 2 or 3 (range, 1-5; Hoehn and Yahr, 1967). All were taking anti-Parkinsonian

medication. Their intellectual functions were evaluated using the Mini-Mental State Examination (MMSE; ≥ 23 demented; < 24 normal; Folstein et al., 1975); three patients who scored under 23 were eliminated from the study as possibly demented and unable to understand instructions. The remaining 16 patients (5 men and 11 women, mean age 68.8 ± 7.30) scored 26.9 ± 1.9 on average. Their visuoperceptual function was checked using two tests. First, they were asked to copy the Rey-Osterrieth Complex Figure (ROCF; Osterrieth, 1944). Their mean score was 32.59 ± 8.2 (n = 12; maximum 36). Although four patients were not tested, they did not show apparent disorder in eyesight. Second, they were given the facial identity discrimination test (FI). They were shown pairs of photographs of women's faces (modified from Nakamura et al., 1999) that lacked nonfacial cues, such as hairstyle, and were asked to judge whether the two faces were the same or different. Their percentage of correct answers was 82 ± 16 % (n = 16). Their depressive states were measured using the Zung Self-Rating Depression Scale (SDS; Zung et al., 1965). Their mean score was 53.9 ± 17.1 (> 40 normal; 40-50 borderline; < 50 depressed), and several were considered depressed (7 depressed, 5 borderline, 2 normal, 2 not tested).

The PD patients were compared to normal controls, who had no history of neurologic or psychiatric illness. There were 24 normal controls for facial stimuli (8 men and 16 women, mean age 64.8 ± 11.7 years), 22 for prosodic stimuli (10 men and 12 women, mean age 64.2 ± 10.0 years), and 21 for written verbal stimuli (10 men and 11 women, mean age 63.1 ± 9.70 years). There were no significant age differences between the PD patients and the controls participating in each type of test. All the participants gave informed consent before participating in this study.

Facial Stimuli

The facial expressions for six basic emotions (happiness, sadness, anger, fear, surprise, and disgust) were expressed by professional male and female actors, and filmed and edited by professional TV production crews. Each emotion was first displayed naturally with no time limit, then with a 2-second time limit. The actors were filmed twice, first head-on and then from a 45-degree angle. Consequently, there were 6 (emotions) × 2 (male and female) × 4 (display types) = 48 stimuli. The videotape had no sound, to ensure that the facial expressions were the only indicator of emotional state. On completion of the videotape, 76 college students rated each expression, and only those expressions that elicited over 80% agreement were used as stimuli (Cronbach's alpha = 0.95). Two female faces showing fear were eliminated by this rule.

In order to check each patient's ability to recognize emotion from static facial expressions, we used the facial stimuli sets from Nakamura et al. (1999), which contain four female faces, expressing happiness, sadness, anger, disgust, and emotionally neutral.

Prosodic Stimuli

The same actors were requested to read four semantically neutral sentences (such as "good morning") and six short, nonsense sentences, and to use tone to convey the six basic emotions, while being recorded on an audiocassette tape. These stimuli were rated by 76 college students, and the 74 prosodies that elicited over 80% agreement were used as stimuli (happiness = 16, sadness = 16, anger = 12, fear = 9, surprise = 11, disgust = 10, Cronbach's alpha = 0.98).

Written Verbal Stimuli

We used the written verbal stimuli from Adolphs et al. (1999), in translation, which consist of 30 sentences (five clear depictions of each of the six basic emotions, such as "This person has just won a new car."). Eighty-four college students rated the sentences, and three sentences (one depicting surprise and two depicting disgust) were eliminated because they did not produce high agreement. The remaining sentences elicited over 80% agreement (Cronbach's alpha = 0.84).

Experimental Design

The experiment was conducted in a comfortable and silent room. The stimuli were presented clearly using a television, tape recorder, or print, as appropriate. Before testing, all subjects were given six cards, with an emotion printed on each, and asked to explain briefly the meaning of each emotion, to confirm that they understood the words. They all understood the six words. In the emotion-recognition tests using facial, prosodic, and written verbal stimuli, the subjects were told to select from the cards the one basic emotion that best described the emotional state represented in the video recording, photograph, tape recording, or sentence. The order of testing using the facial, prosodic, and written verbal stimuli was counterbalanced between patients. The stimuli were presented one at a time, in randomized order. The subjects were instructed to consider all six alternatives carefully before responding. There was no time limit, and the cards or photographs remained in the subjects' view throughout the test. The recorded stimuli were presented repeatedly if requested. No feedback was given as to the correctness of the answers.

RESULTS

Emotion Recognition from Moving Facial Stimuli

The percentage of correct responses for each emotion is shown in Table I. Since there were no significant differences in the performances according to stimulus duration or angle, we calculated the mean scores for each emotion regardless of the display type. The performances of PD patients were less accurate than controls, except for happiness and sadness, for which both PD patients and controls performed perfectly. We compared their performances using a repeated measures analysis of variance (ANOVA), with the factors participant group (PD patients and control) and emotion (the six basic emotions). There were significant main effects of group [$F(1, 38) = 16.0$, $p < 0.01$] and emotion [$F(5, 38) = 32.9$, $p < 0.01$], and the interaction between group and emotion was also significant [$F(5, 190) = 6.71$, $p < 0.01$]. We examined the simple main effect and found that PD patients' recognition of fear and disgust was impaired compared to that of control subjects [$F(1, 38) = 11.65$, $p < 0.01$; $F(1, 38) = 4.41$, $p < 0.05$, respectively]. A post hoc comparison using least significant difference (LSD) analysis revealed that PD patients recognized fear and disgust less well than the other four emotions, and that fear was the emotion least recognized by both PD patients and controls ($MSe = 165$, $p < 0.05$).

TABLE I

Performance in Each Test by Parkinson's Disease Patients (PD) and Controls (NC)

			Emotion					
			Happiness	Sadness	Anger	Fear	Surprise	Disgust
Facial videotape	PD	Mean	1.00	1.00	0.95	0.55**	0.94	0.84*
		SD	0.00	0.00	0.09	0.30	0.12	0.18
	NC	Mean	1.00	1.00	0.98	0.83	0.96	0.94
		SD	0.00	0.00	0.05	0.20	0.08	0.12
Prosodic stimuli	PD	Mean	0.69	0.74	0.72	0.57	0.77	0.62
		SD	0.17	0.12	0.12	0.22	0.23	0.26
	NC	Mean	0.77	0.84	0.70	0.62	0.78	0.61
		SD	0.25	0.13	0.17	0.20	0.15	0.25
Written verbal stimuli	PD	Mean	0.93	0.88	0.86	0.83	0.79	0.80
		SD	0.14	0.14	0.20	0.17	0.15	0.19
	NC	Mean	0.90	0.87	0.95	0.88	0.81	0.89
		SD	0.16	0.11	0.11	0.14	0.18	0.16

**$p < 0.01$; * $p < 0.05$. Mean scores (rates of correct answers) are shown with the standard deviation (SD).

Emotion Recognition from Prosodic Stimuli

Table I shows the subjects' performance. A 2 × 6 (group × emotion) ANOVA with repeated measures demonstrated a main effect of emotion [$F(5, 35) = 7.76$, $p < 0.01$]. There was no significant effect of group or group × emotion interaction. A post hoc comparison using LSD analysis revealed that fear and disgust were recognized less than the other four emotions ($MSe = 305$, $p < 0.05$).

Emotion Recognition from Written Verbal Stimuli

Table I shows the subjects' performance. A 2 × 6 (group × emotion) ANOVA with repeated measures revealed a main effect of emotion [$F(5,33) = 2.65$, $p < 0.05$]. Similarly, the effects of group and group × emotion were not significant. A *post hoc* comparison using LSD analysis revealed that surprise was less well recognized than happiness or anger, and recognition of disgust was worse than recognition of happiness ($MSe = 237$, $p < 0.05$).

Comparison of Recognition of Moving and Static Facial Expressions

We compared the PD patients' results for moving and static facial expression recognition of happiness, sadness, anger, and disgust, which were common to both tests (Figure 1). A 2 × 4 (type of stimulus × emotion) ANOVA with repeated measures showed that there were significant main effects of type of stimulus [$F(1, 15) = 195$, $p < 0.01$], emotion [$F(3, 45) = 11.7$, $p < 0.01$], and the interaction between type of stimulus and emotion [$F(3, 45) = 6.37$, $p < 0.01$]. The simple main effects of type of stimulus were significant in the case of sadness, anger, and disgust [$F(1, 15) = 35.0$, $p < 0.01$; $F(1, 15) = 15.0$, $p < 0.01$; $F(1, 15) = 19.7$, $p < 0.01$, respectively]. A post hoc test using LSD

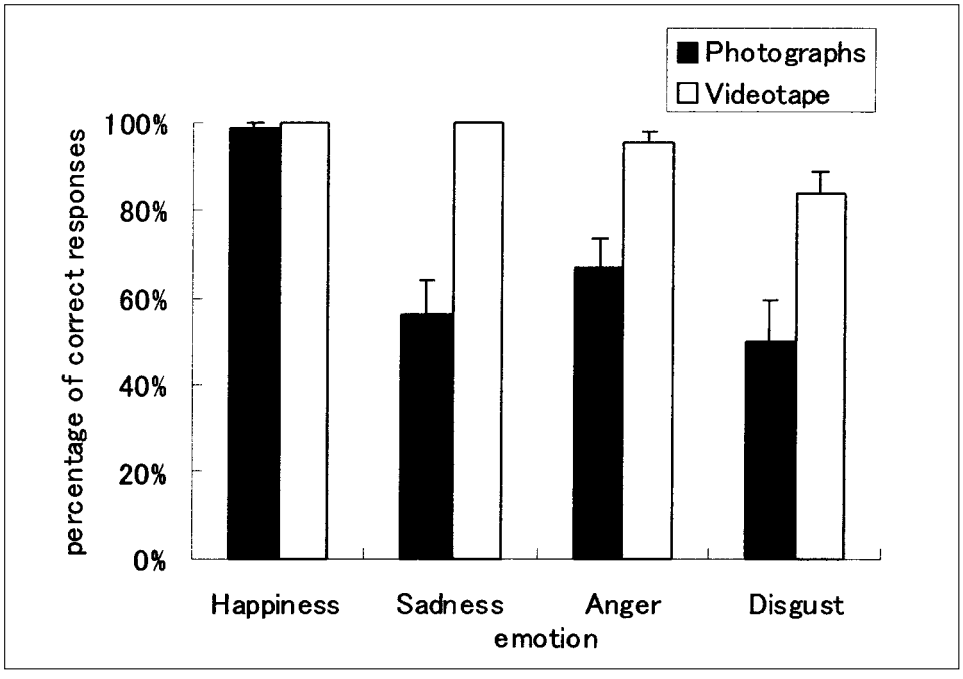

Fig. 1 – *Comparison of the average performance of PD patients in recognizing moving and static facial expressions. The error bars show the standard error. PD patients performed better with video recordings than with photographs when asked to recognize sadness, anger, and disgust ($p < 0.01$ for all).*

analysis showed that disgust was the emotion that was least recognized in video recordings, and happiness was the emotion most often recognized in static faces (MSe = 106, $p < 0.05$).

Correlations between Each Test

We computed the correlations for the results of each test for the PD patients, and the scores on the MMSE, ROCF, FI, and SDS (Table II). The numbers in parentheses indicate the number of people that completed each test. Statistically significant correlations were seen within the scores of the emotion recognition tests (facial videotape recordings, facial photographs, and prosodic stimuli, all $p < 0.05$). There were no significant correlations between the MMSE and any other test results. The ROCF score was significantly correlated only with FI ($p < 0.01$). SDS scores were negatively correlated with the scores of the emotion recognition test using written verbal stimuli ($p < 0.05$).

TABLE II

Pearson Correlations between Each Test and Other Control Measures for PD Patients

	Emotion recognition							
	Facial videotape	Facial photo	Prosodic stimuli	Written verbal stimuli	MMSE	ROCF	FI	SDS
Emotion recognition								
Facial videotape (16)	1							
Facial photo (16)	0.43*	1						
Prosodic stimuli (15)	0.58*	0.59*	1					
Written verbal stimuli (14)	0.02	– 0.01	0.19	1				
MMSE (16)	0.06	– 0.22	0.26	0.12	1			
ROCF (12)	0.19	0.04	0.40	0.31	0.17	1		
FI (16)	0.21	– 0.05	0.37	0.31	0.39	0.87**	1	
SDS (14)	0.3	– 0.07	0.09	– 0.55*	– 0.02	– 0.47	– 0.07	1

**$p < 0.01$; * $p < 0.05$. The numbers in parentheses are the number of subjects that completed each test.

Since the fear and disgust scores in the videotape task were significantly lower in PD patients than in normal controls, we calculated individual correlation coefficients with other tests. The only significant positive correlation was between fear and SDS score (0.47, $p < 0.05$). Other correlations didn't reach significance (the coefficients of fear with MMSE, ROCF, and FI were – 0.10, 0.18, and 0.10, respectively. The coefficients of disgust with MMSE, ROCF, FI, and SDS were 0.10, 0.04, 0.07, and 0.10, all $p > 0.05$).

DISCUSSION

PD patients showed low accuracy in recognition of moving facial expressions, especially in recognizing fear and disgust. Statistically significant differences between PD patients and controls were seen in fear and disgust, suggesting that the PD patients' impairment was larger for these two emotions than for others. In line with studies of patients with selective amygdala lesions (Adolphs et al., 1994) or Huntington's disease (Sprengelmeyer et al., 1996), in which emotion-recognition impairment appears to be more severe for some emotions than for others, it is possible that emotions are not interpreted together, but have a degree of multiple neural substrates. Functional neuroimaging studies examining the neural basis of facial emotion recognition have shown the involvement of the amygdala in processing fear (Morris et al., 1996; Phillips et al., 1997, 1998; Whalen et al., 1998) and the involvement of the striatum or insula in processing disgust (Phillips et al., 1997, 1998; Sprengelmeyer et al., 1998). The striatum, the largest part of the basal ganglia, plays a major role in the pathology of PD. There is some evidence that the amygdala is affected in early PD, as well as the striatum (Mattila et al., 1999; Ouchi et al., 1999).

In addition, there were no significant differences between PD patients and controls in the recognition of emotion from prosodic and written verbal stimuli. This means that PD patients can recognize fear and disgust via auditory information or verbal meaning. Similarly dissociated impairment in recognizing emotion from visual and auditory stimuli has been reported in patients with amygdala lesions (Fine and Blair, 2000), although the reasons for this are not clear. The dissociation suggests that the neural substrates involved in emotion recognition have a degree of modality-specificity, and the basal ganglia may play a more important role in recognizing visually presented emotions than it does in recognizing auditory stimuli.

Patients were better at recognizing moving facial expressions than static ones. This suggests that dynamic information helps PD patients to recognize sad, angry, and disgusted facial expressions. In a previous study, Kilts et al. (1996) showed that the recognition of static facial expressions activates somatosensory and frontal premotor regions of normal subjects. These regions are implicated in motor imagery, and Kilts et al. suggested that recognizing static facial expressions requires implicit imagery of the motor patterns of each facial expression, and matching a static percept with these motor images. The brain activation of PD patients during motor imagery is abnormal; the dopaminergic deficit results in excessive inhibition of thalamo-frontal/premotor projections from the basal ganglia (Thobois et al., 2000). It is therefore plausible that PD patients have difficulty in recognizing static facial expressions because of a deficit in motor imagery. From this perspective, it is possible that less motor imagery is required to recognize happy faces than to recognize other facial expressions, since happy faces are readily recognizable from static photographs.

Why was the recognition of PD patients impaired only for faces showing fear and disgust? First we must consider the hypothesis that they have difficulty in recognizing facial expressions that are difficult for even normal subjects to interpret, such as fear and disgust. Rapcsak et al. (2000) attributed fear-recognition deficits to task difficulty. However, although the performance of the normal controls was worst for the face showing fear, their performance for disgust did not differ from that for the remaining four emotions. Furthermore, PD patients could recognize fearful voices, even though fear was again the emotion least well-recognized by controls in the emotional voice recognition test. Therefore, the level of difficulty alone cannot account for these impairments. Second, we should consider the influence of the patients' intellectual, visuoperceptual, or depressive state. However, correlation analysis showed no significant correlation between the accuracy of recognizing faces showing fear or disgust and other measures, neither in a previous study (Adolphs et al., 1998) nor in this study. In this study, the only significant correlation seen was a positive correlation between recognition of a face showing fear and SDS score. This implies that the more depressed a patient becomes, the more accurately they can recognize fear from faces, so deep depression does not explain the low accuracy in recognizing faces showing fear.

Another explanation arises from evolutionary psychology. Both fear and disgust are emotions concerned with "avoiding danger". Learning not to approach objects that others are avoiding (e.g., predators or rotten food) may be critical for survival. This learning may involve the basal ganglia, which are thought to be dedicated to visuomotor associations and to learning stimulus-response habits. It has been reported that patients with Huntington's disease, which also targets the basal ganglia, show deficits in recognizing facial expressions (Jacobs et al., 1995b), notably disgust (Sprengelmeyer et al., 1996). Sprengelmeyer et al. (1996) suggested that the integration and learning of behavioral responses may be more significant for disgust than for other basic emotions, and the same is true for fear.

The correlation analysis suggests that the scores of MMSE or SDS do not relate to emotion recognition. In addition, the data show that the visuoperceptual function, examined here by ROCF, is significantly correlated with FI, the perception of facial identity from faces, but not with facial expression recognition. This suggests that facial expression recognition involves more than mere visuoperception, although this should be interpreted carefully, because of the relatively small number of participants in the ROCF ($n = 12$). The positive correlation between tests using facial and prosodic stimuli means that both tests measure the ability to recognize emotion, regardless of the stimulus type. The score of the test using written verbal stimuli did not correlate significantly with the other emotion

recognition test scores, and was negatively correlated with the degree of depression. This test requires a subject to interpret the emotion of the person described by putting himself or herself in that person's place. Due to this aspect of the test, it might differ from the other two emotion recognition tests, and might be affected by a subject's mood.

Since the videotaped stimuli were designed to be highly recognizable, it may have been too easy for both PD patients and normal controls to detect happiness and sadness, as represented in the perfect performances. It is possible that there may be differences in the accuracy of the two groups when recognizing happiness and sadness from more subtle and ambiguous faces. In everyday life, people encounter subtle and ambiguous facial expressions, not only obvious and exaggerated facial expressions such as those used in this study. Therefore, it may be important to examine emotion recognition using more ambiguous facial expressions. Furthermore, in this study, we found a positive correlation between the accuracy of recognition of a face showing fear and depressive state. Since correlation analysis does not determine causal associations, it remains unclear whether PD patients can detect fear more accurately because of their more depressed state, or whether PD patients become more depressed because they are too sensitive to faces showing fear. These matters remain for future research.

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